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13. ABSTRACT *(Maximum 200 words)*

The principal objective of this project is to determine the most efficient means of encloding a microwave/millimeter-wave signal from a patch antenna onto an optical carrier in an electro-optic substrate for subsequent optical processing of the microwave/millimeter-wave signal. Our approach during the last period has been to continue the development of design models that would relate the performance of integrated electro-optic devices to the fabrication parameters used in making them. Our emphasis has been on the design and fabrication of coplanar waveguides for electro-optic devices. This includes the design of a coplanar waveguide coupler at 5 GHz. A new technique for analyzing discontinuities in coplanar waveguides was also developed.

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SEMI-ANNUAL PROGRESS REPORT

for Office of Naval Research
for the period June 1, 1992 through November 30, 1992

1. Contract Title:

An Investigation of the Channel Crosstalk in Optical Heterodyne Controlled Phased Array Radars

Principal Investigators:

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Boulder, CO 80309-0425

Program Manager:

Dr. Arthur Jordan

2. Technical Objectives:

The principal objective of this project is to determine the most efficient means of encoding a microwave/millimeter wave signal from a patch antenna onto an optical carrier in an electro-optic substrate for subsequent optical processing of the microwave/millimeter wave signal.

3. Approach:

Our approach during the last period has been to continue the development of design models that would relate the performance of integrated electro-optic devices to the fabrication parameters used in making them. Our emphasis has been on the design and fabrication of coplanar waveguides for electro-optic devices. This includes the design of a coplanar waveguide coupler at 5 GHz. A new technique for analyzing discontinuities in coplanar waveguides was also developed.

4. Accomplishments:

Our research in the area of single sideband modulation of an optical carrier by a millimeter wave has resulted in several modeling techniques. This includes the modeling of proton exchanged waveguides and the modeling of the overlap of microwave and optical signals in optical modulators.

By starting with the refractive index profile, and using the effective refractive index method, we can determine the modal field distributions, propagation constants and coupling coefficients of channel waveguides. The effect of a buffer layer between the optical waveguide and the microwave electrodes on the optical depth of modulation can also be determined. This buffer layer reduces the optical loss of the waveguide.

Coplanar waveguides are the ideal structures for multi-layer devices. Most of our efforts have been toward improving the modeling of coplanar waveguide structures for such applications as 3 dB couplers and optical modulators.

We have developed a new technique, based on a quasi-static formulation, for computing the frequency dependent scattering parameters for nonuniform coplanar waveguide structures. The technique is substantially faster than full-wave techniques, and for sufficiently small line dimensions compared to the wavelength, the accuracy should rival that of full-wave techniques.

We transform the two-dimensional quasi-static charge distribution on the discontinuous transmission line into an equivalent nonuniform transmission line. Since the quasi-static current distribution is divergenceless, a unique local coordinate system on the center conductor can be defined

from the current field lines and their normals. This defines a curvilinear coordinate system of the equivalent transmission line. The transmission line parameters are expressed in terms of the static charge distribution. The propagation along the equivalent transmission line, therefore, recovers the full dynamics of the scattering problem from the static charge distribution.

This technique has been applied to a double step-in-impedance discontinuity, computing the S-parameters up to 40 GHz. These results compared well to the results from a full-wave analysis of the same structure up to 30 GHz (Figures 1 and 2).

We have also built a coplanar 3 dB branch coupler for use in a single side band modulator. The coupler uses various impedance sections to achieve the 3 dB coupling and was designed to work at 5 GHz (Figure 3). It will provide 50 ohm drivers to two resonant electrodes.

5. Significance:

From our theoretical and experimental work, it has been shown that it is feasible to build a single side band modulator for millimeter/microwave signals. A thorough investigation of coplanar electrodes may improve the design of resonant electrodes for electro-optic modulators.

6. Future Efforts:

Our efforts will continue in coplanar electrode structures. Results from another project aimed at building optical devices on nonlinear optical polymeric materials may be applied to the single sideband modulator. This would provide new materials with possible greater electro-optic effects.

7. Publications and Presentations Partially Supported Under This Grant October 1, 1991 Through September 30, 1992

Please see the attached complete list of publications.

(a) D.R. Hjelme, A.R. Mickelson, "Voltage Calibration of the Direct Electrooptic Sampling Technique," IEEE Micro. Theory and Tech, 40, see also Guided Wave Optics Laboratory Report No. 31 (April 1991).

(b) I. Januar, R.J. Feuerstein, A.R. Mickelson and J.R. Sauer, "Wavelength Sensitivity in Directional Couplers," Jour. Lightwave Tech., 10, p.1-8 (1992)

(c) M.J. Yadlowsky, D.R. Hjelme and A.R. Mickelson, "Power Coupling and Time-Dependent Radiative Transfer in Guided Wave Systems," Journ. Opt. Soc. Am A, (August 1992).

(d) D.R. Hjelme and A.R. Mickelson, "Theory and Timing Jitter in Actively Modelocked Lasers," IEEE Journ. Quant. Elect., JQE-28, 1594-1606 (June 1992).

(e) P.J. Matthews and A.R. Mickelson, "Analysis of an Integrated Optical Coherent Receiver with Optical State of Polarization Control, Fiber and Integrated Optics, 10, pp. 137-165, (December 1991).

Guided Wave Optics Laboratory Reports

(a) I. Januar, R.J. Feuerstein, A.R. Mickelson, and J.R. Sauer, "Wavelength Sensitivity in Directional Couplers," September 1992, GWOL-45.

(b) D.R. Hjelme, M.J. Yadlowsky, A.R. Mickelson, "Two-Dimensional Mapping of the Microwave Potential on MMICs Using Electrooptic Sampling," June 1992, GWOL-44.

(c) M.J. Yadlowsky, A.R. Mickelson, "Distributed Loss and Mode Coupling and Their Effect on Time Dependent Propagation in Multimode Fibers," June 1992, GWOL-43.

(d) P.J. Matthews, A.R. Mickelson, "Instabilities in Annealed Proton Exchange Waveguides in Lithium Tantalate," April 1992, GWOL-41.

(e) P.J. Matthews, A.R. Mickelson, S.W. Novak, "Properties of Proton Exchange Waveguides in Lithium Tantalate," April 1992, GWOL-40.

(f) M.R. Surette, D.R. Hjelme, R. Ellingsen, A.R. Mickelson, "Effects of Noise on Transients of Injection Locked Semiconductor Lasers," December 1991, GWOL-38.

(g) A.R. Mickelson, Z.B. Popović, "A Five-Terminal Optical Switch," December 1991, GWOL-37.

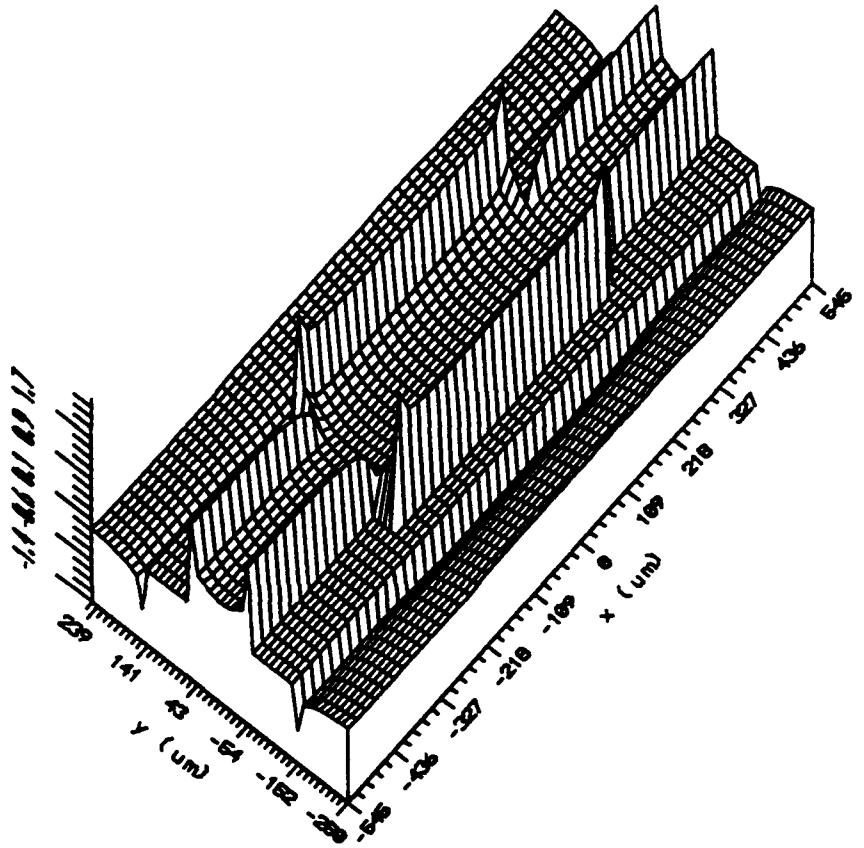
Theses During Project

(a) M.R. Surette, "Effects of Noise on Transients of Injection Locked Semiconductor Lasers."

(b) P.J. Matthews, "Instabilities in Annealed Proton Exchange Waveguides in Lithium Tantalate."

8. Participants

Professor Alan R. Mickelson
Hyesook Hong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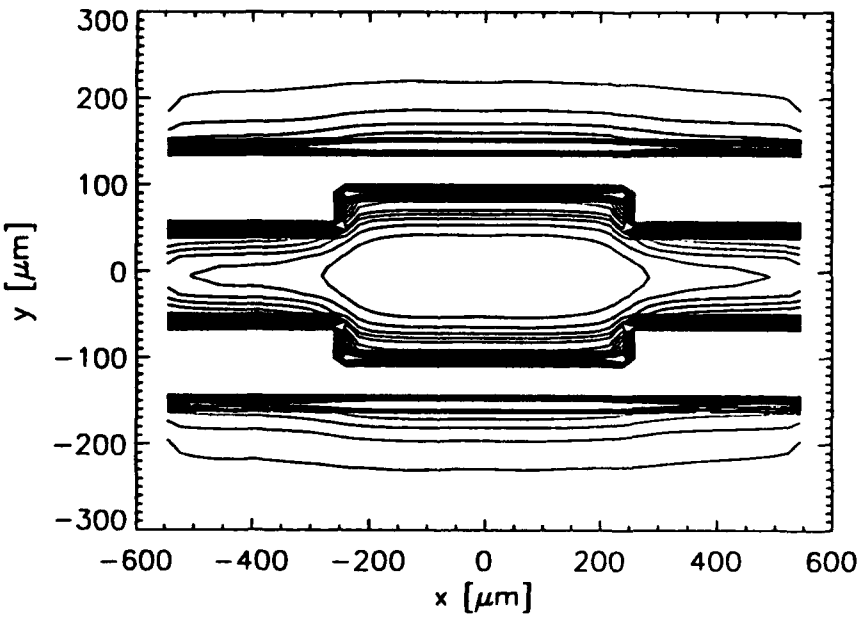
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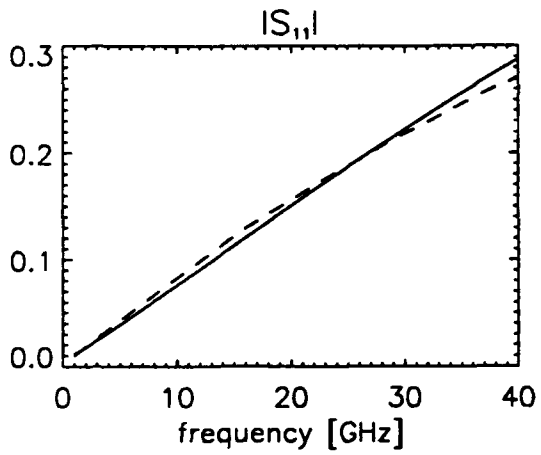
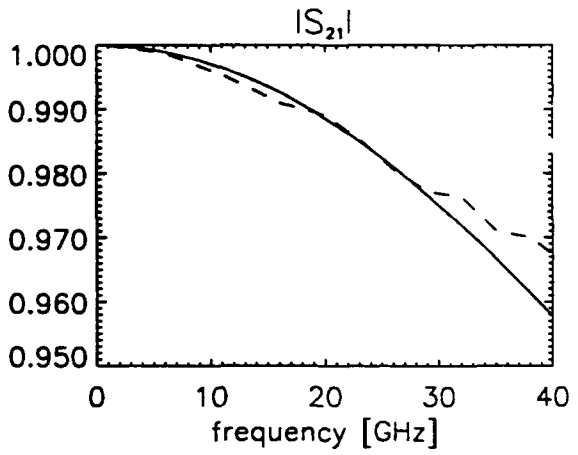
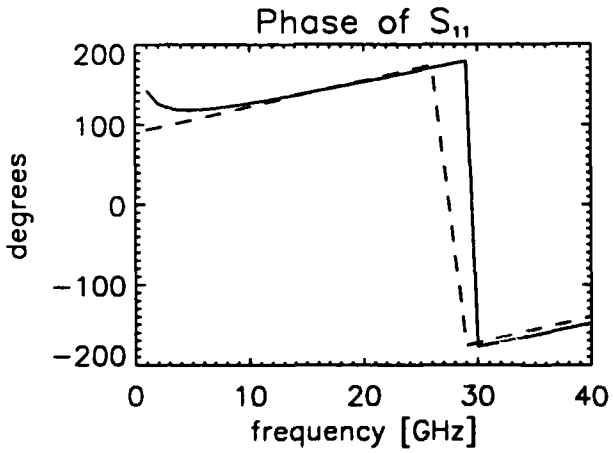
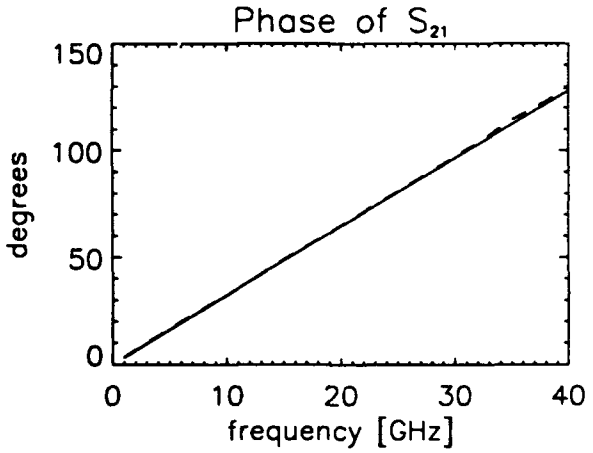
S-Parameters
Compared with a Full-Wave Analysis









3 dB Branch Coupler